$^{233}U(^{3}He, xn)^{236-x}Pu$ Excitation Function Study

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The neutron deficient plutonium region had not been investigated until Andreyev et al. identified the new isotopes, ^{230}Pu[1)] and $^{228/229}Pu$[2)] using the cinematic separator VASSILISSA. In $^{208}Pb(^{24/26}Mg, xn)$ reactions they measured the α-decay energies of the Pu-isotopes, but could not determine half-lives or branching ratios for the decay modes. Until then, the lightest plutonium isotope known was ^{232}Pu.

In the present study, to understand production and decay properties of these highly neutron-deficient actinides, the light plutonium isotopes were made with highly asymmetric $^{233}U(^{3}He, xn)$ reaction. Several studies with ^{4}He projectiles and uranium targets were done[3], while the (^{3}He, xn) reaction remained mostly unexplored. A previous study[4] showed that production cross sections do not occur as expected.

A ^{3}He beam with projectile energies of 30, 36, 40, 42, 48, 54, 60 and 72 MeV in the laboratory frame and an average intensity of 8 eμA was used to bombard 8 ^{233}U targets (40 μg/cm^2) arranged in the LIM (Light Ion Multiple)[5] target system. Interactions of projectiles with the target system caused an energy spread in the target stack ranging from 6 MeV to 1.4 MeV from the lowest to highest projectile energies, respectively.

Recoils were swept out of the target system using a KCl-seeded He-jet and were transported to the remote collection site. The collected samples were chemically[6] purified and were analyzed by α-spectrometry. Frequent repeats of each collection were performed in order to obtain a good statistics. The chemical separation was necessary to remove interfering activities, such as directly produced Np and U isotopes, as well as daughters produced from Pu decay during collection.

Cross section calculations were done under the assumption of 60% He-jet, 40% chemical and 30% detector efficiency*. Results for $^{233}U(^{3}He, 4n)^{232}Pu$ reaction cross section are shown in the figure and appear to be less than 1 μb. These results were compared to the experimental data taken from ref. 3 and with the predictions of the widely used SPIT code[7]. Due to the observable discrepancies, work with other codes will be done as well as further experimental studies.

Footnotes and References

* To normalize the data a catcher foil experiment was performed, these data have still to be analyzed.

1. A.N.Andreyev et al. Z. Phys. A, 337 (1990) 231.
2. A.N.Andreyev et al. Z. Phys. A, 347 (1994) 225-226.
3. H.Delagrange et al., Phys Rev C 17/5 (1978) 1706.
4. M.B.Hendricks et al., LBLAnnual Report 1996.
5. H.L.Hall et al., Nucl.Instrum.Meth., A279(1989) 649.
6. C.A.Laue et al., contribution to this report.
7. The SPIT code is similar to JORPLE code, but has a more realistic potential for the entrance channel. JORPLE reference is: J.Alfonso, Gmelins Handbuch der Anorg. Chemie, Weinheim, Bd 7b, A1, p.29, 1973.

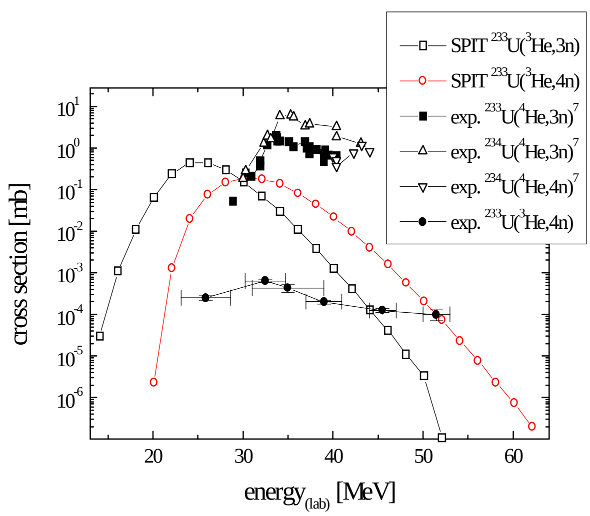

Fig. Comparison of experimentally determined cross sections for $^{233}U(^{3}He,4n)$ ^{232}Pu reaction with other similar experimental data from ref. 3 and predicted cross sections from the SPIT codes for the 3n and 4n reaction.